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of interest. Without any other information, we may consider both models equally likely to occur and assign equal *prior* probabilities to each model. That is,

$$\Pr(p = 0.17) = 0.50$$
$$\Pr(p = 0.22) = 0.50$$

Assigning a *prior* distribution is often based on historical information, previous literature, expert opinion, or other appropriate sources. This assignment is subjective in nature, and there is no single ‘correct’ *prior* distribution. This is the most common criticism of Bayesian analysis. However, the *prior* distribution has less influence on analysis results as sample size increases.

Next, our previous knowledge (*i.e.*, *prior*) is combined with our observed data to calculate *posterior* probabilities. The *posterior* probabilities represent the probability of each model given the observed data, and calculations are obtained using the following conditional probability relationship:

$$\Pr(\text{model}|\text{data}) = \frac{\Pr(\text{model \& data})}{\Pr(\text{data})}$$

For instance, suppose that we observe one astronaut (1a) who does not have a cataract (0c). Combining this information with our *prior* probabilities we have

$$\Pr(p = 0.17 | 1a, 0c) = \frac{(0.50)(1 - 0.17)}{(0.5)(1 - 0.17) + (0.5)(1 - 0.22)} = 0.52$$
$$\Pr(p = 0.22 | 1a, 0c) = \frac{(0.50)(1 - 0.22)}{(0.5)(1 - 0.17) + (0.5)(1 - 0.22)} = 0.48$$

The probabilities are then updated with the next observation using the previous calculation as the *prior* probabilities. Suppose the second observation is an astronaut (2a) who has a cataract (1c), then the *posterior* probabilities are

$$\Pr(p = 0.17 | 2a, 1c) = \frac{(0.52)(0.17)}{(0.52)(0.17) + (0.48)(0.22)} = 0.46$$
$$\Pr(p = 0.22 | 2a, 1c) = \frac{(0.48)(0.22)}{(0.52)(0.17) + (0.48)(0.22)} = 0.54$$

According to Cucinotta *et al.*<sup>2</sup>, 48 out of 295 astronauts had developed cataracts as of 2000. In this case, the *posterior* probabilities are

$$\Pr(p = 0.17 | 295a, 48c) = 0.95$$
$$\Pr(p = 0.22 | 295a, 48c) = 0.05$$

Thus, Bayesian analysis strongly supports no difference between the prevalence of cataracts in astronauts versus the U.S. population over 40 years of age because there is 95% probability that the true prevalence of cataracts in astronauts is  $p = 17\%$ . There is only a 5% probability that the true prevalence of cataracts in astronauts is  $p = 22\%$ . Note, however, that this example is provided for explanatory purposes only and should not be interpreted as a thorough analysis of this dataset. Cucinotta *et al.*<sup>2</sup> did not compare cataract incidence in astronauts to the incidence in an external population. They reported an increased risk of cataracts in astronauts with higher lens doses of space radiation compared to astronauts with lower lens doses. More sophisticated Bayesian analyses may consider many (*i.e.*, infinite) alternative models, confounding variables, and time to cataract development. ■

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**For your information**

If you want a copy of your exam results, please complete and sign a release form while you are visiting the Clinic for your examination. The form is called *Privacy Act Disclosure Authorization and Accounting Record (DAAR)*, or NASA Form 1536.

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THE LONGITUDINAL STUDY OF ASTRONAUT HEALTH

# Newsletter

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## A Brief Introduction to Bayesian Statistics

BY CHARLES MINARD, PhD

Many researchers are surprised to learn that there are two branches of statistics that fundamentally differ in approach to statistical inference: Frequentist and Bayesian. Both methods may be used to answer statistically relevant questions; however, each method requires different assumptions and interpretation of analysis results. Historically, Frequentist statistics have dominated the literature, but Bayesian statistics have become an increasingly popular alternative in recent years. The purpose of this article is to

provide an introduction to Bayesian analysis.

One of the most common problems in epidemiologic research is to compare the occurrence of adverse events between two groups of people. Consider the prevalence of cataracts in astronauts compared with that of the U.S. population. The prevalence ( $p$ ) of cataracts among Americans at least 40 years of age is about 17%.<sup>1</sup> Now suppose that we are interested in whether cataract prevalence in the astronauts is the same as or 5% greater than the U.S. population. We

might consider two possible models for the prevalence of cataracts in astronauts:  $p = 17\%$  and  $p = 22\%$ . Bayesian analysis asks “What is the probability of the model given the observed data?”:

$$\Pr(\text{model} | \text{data})$$

This is opposed to the Frequentist methodology which asks “What is the probability of the observed data given the model?”:

$$\Pr(\text{data} | \text{model})$$

The first step in Bayesian analysis is to establish a *prior* distribution for the parameter

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## Ten Steps to Consider Before Taking Over-the-counter Medications

BY ADRIANA BABIAK-VAZQUEZ, MPH

The use of over-the-counter (OTC) medications has been steadily increasing through the years. Unfortunately, the precautions we take in the use of self-medications have not increased. Of particular concern is consumption of multiple OTC medications, sometimes in conjunction with prescribed medications for unrelated acute or chronic diseases.

It is this ‘mixing and matching’ in actual use that can prove dangerous to our health since most medications, OTC or prescription, have not been clinically tested in the myriad of combinations possible. Some OTC medications are actually combinations of several medications which treat different symptoms. One popular OTC cold and flu medication contains acetaminophen, chlorpheniramine maleate, dextromethorphan hydrobromide, and phenylephrine. This OTC medication

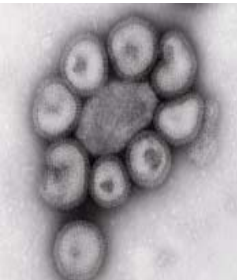
advertises that it “relieves the headache, body aches, minor sore throat pain, and fever that accompany colds and flu. It also unclogs stuffy nose and sinuses, relieves coughs due to minor throat and bronchial irritation, and combats runny nose, sneezing, itchy nose and throat, and itchy, watery eyes.” Therefore, often as we combine OTC drugs with each other or with prescription medications, we

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# Pandemic Flu: a Public Health Concern or Urban Legend?

BY HEATHER J. HARTNETT, Ph.D

There are alligators in the New York sewers! If you eat pop rocks and drink soda at the same time, your stomach will explode! We have all heard these urban legends, but how important are the warnings about the “imminent” pandemic flu outbreak? As flu season approaches, it is important to educate ourselves about this ever evolving virus and this public health issue.



Influenza virus particles  
From CDC/Dr. F.A. Murphy

A pandemic is defined as a global disease outbreak. A flu pandemic occurs when a new influenza virus emerges for which people have little or no immunity, and for which there is no vaccine. The disease spreads easily person to person, can cause serious illness, and can sweep across the country and around the world in very short time. In the past 400 years, a total of 32 pandemics have been recorded with the first described in 1580; in the past century, three major influenza pandemics occurred in 1918, 1957, and 1968. The pandemic of 1918-1919 was felt in three waves and was by far the most devastating, resulting in the death of 20 to 40 million disproportionately young people worldwide.<sup>1</sup>

One of the most important features about influenza viruses is that their structure evolves over time. This process results in the appearance of different strains that circulate each year. For this reason, the composition of the influenza vaccine is changed annually to help protect people from the strains of influenza virus that are

expected to be the most common during the coming influenza season. Currently, there are three distinct influenza virus strains in general circulation in humans: seasonal influenza, avian flu, and potentially pandemic organisms such as H5N1 commonly called “bird flu.”

Since 2003, a growing number of human H5N1 cases have been reported in Asia, Europe, and Africa. According to the World Health Organization, WHO, 61% of the people infected with the H5N1 virus died with most of these cases attributed to the ingestion of infected poultry. In addition, there has been documented human-to-human transmission in clusters extending three generations. For this reason, there is potential for this virus to travel around the world quickly and cause serious illness and deaths. The next pandemic, an event considered by many experts to be inevitable and overdue, will greatly affect the way health care is provided. It is assumed that the virus is already in the USA since it has been found elsewhere in the world.

To compensate for the ever changing flu virus, the pandemic preparedness response focuses on detecting circulating strains through virologic surveillance and evaluating morbidity and mortality. The influenza vaccine and antivirals such as amantadine, rimantadine, zanamivir (Relenza®), and oseltamivir (Tamiflu®) form part of the control and prevention of influenza. Other measures, including severely limiting travel, may also be employed to slow the spread of the virus. All state and local governments are required to have an emergency management plan that addresses all hazards. The emergency management plans of hospitals, nursing homes, schools, and other congregate settings should incorporate a pandemic influenza plan in addition to their existing plans. In addition, it is also recommended

that physician practices develop plans to manage the large numbers of patients seeking care. However, these plans are very difficult to construct and implement given the dynamics of our current system.

The Centers for Disease Control and Prevention (CDC) has estimated that pandemic flu could affect 25% to 50% of the national population. The estimated case fatality rate is 1.5% to 5%. This suggests approximately 88,000 to 580,000 deaths could occur in Texas (see below). These numbers depend on virus transmissibility, virulence, vaccine availability, and personal protective behaviors that can potentially reduce exposure and transmission.

### Texas pandemic flu case fatality estimate

The low end of the estimate is calculated by using the low values for attack and fatality rates, as follows:  
2006 Texas population = 23,507,78.  
Attack rate = 25%,  
so population infected = 5,876,946  
Fatality rate = 1.5%,  
so deaths from those infected = 88,154

The high end of the estimate is calculated by using the high values for attack and fatality rates, as follows:  
Attack rate = 50%,  
so population infected = 11,753,892  
Fatality rate = 5%,  
so deaths from those infected = 587,695

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“OTC”, continued from page 2

are experimenting on ourselves and risking unintended consequences.

For example, if we take one OTC medication, such as acetaminophen, for pain, consume another OTC medication for flu symptoms control and then drink some wine for anxiety relief, we could have the beginnings of a major problem. Acetaminophen and the other flu symptom medications and wine, when overused or not taken as directed, can be toxic to the liver. Each individually may cause irreparable damage, but when taken together even more serious injury or death may occur.



If you are not a toxicologist, pharmacist or physician, how can you avoid these dire consequences? Consider the following ten steps recommended by the Food and Drug Administration before consuming OTC medications:

1. PRODUCT NAME: Take note of both the generic and brand names. The names can provide clues that perhaps that medication is also contained in another product you are taking.
2. ACTIVE INGREDIENTS: It is very important to note all the main ingredients in the therapeutic product to avoid accidentally overdosing on the ingredient found in other medications you may be taking.
3. PURPOSE or USES: Know what this non-prescription medicine is treating and what the purpose of consumption is. The two are not necessarily the same; for example you may take a fever-reducer when you actually need a painkiller, or you may take a cough suppressant when you need an antihistamine or a decongestant, or you may actually need a combination of all of the above.
4. SIDE EFFECTS: Be aware of possible side effects or reactions that may occur when taking a particular OTC medication. Note what steps you need to take if these symptoms occur (e.g., “Call physician immediately”).
5. WARNINGS: Know what activities to avoid when taking medication (e.g., “don’t operate a moving vehicle while on medication”). Also, note if the medication is not suitable for people with certain diagnoses or chronic health problems (e.g., people with glaucoma, thyroid disease, diabetes, hypertension or on hypertensive medicines).
6. DIRECTIONS: Ask yourself these questions: How much should you take a day, per dose (i.e., how many pills at a time)? When should you take it (i.e., time of day, before or after a meal)? How long should you take it or what period of time not to extend (e.g., “do not use longer than 5 days without seeing a physician”)? How should you take it (e.g., with a full glass of water or with food or on an empty stomach)?
7. SPECIAL INSTRUCTIONS: Note if there are special instructions and follow them (e.g., “Patients should avoid sun exposure when taking this medication”).
8. INACTIVE INGREDIENTS: These are substances such as flavoring or color added or binding. Sometimes these ingredients can cause allergic or unexpected reactions, especially in chemically sensitive people.
9. EXPIRATION DATE: Discard promptly after reaching expiration date. Expired therapeutic products may not work as effectively and in some cases can be harmful if ingested.
10. STORAGE INFORMATION: Be aware if the OTC medication needs to be kept refrigerated or in a cool area. Not all packaging indicates this clearly; some packaging may simply list a temperature

range for storage. Do not leave medications on the window sill, in a car, in your luggage, or in a warm house. All these conditions can leave medications exposed to heat or cold. Also, note if the medication needs to be protected from light. This is especially important when removing pills from an original container and placing them in another container that may not have special tinting for light protection.

Keeping these ten items in mind may save a lot of aggravation and heartache. Remember, there is nothing on the therapeutic product label that is placed there lightly or as a general statement. If you need additional information or clarification about both OTC medications and their specific interactions with prescription medications, consult with your pharmacist and/or with your physician. It is imperative to your health that your physician know all of the medications you are taking, either with or without a prescription. Help your doctor and pharmacist to help you to stay safe—keep them informed of the OTC and prescription medications you are taking. ■

“Pandemic flu”, continued from page 2

In conclusion, it appears this threat carries more merit than alligators in the sewers or eating pop rocks and drinking soda, so be sure to get a flu shot, contain the flu by staying home when you are sick, and washing your hands frequently.

For more information on pandemic flu, visit the Centers for Disease Control and Prevention website, [www.cdc.gov](http://www.cdc.gov), or the World Health Organization website, [www.who.int](http://www.who.int). ■

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1. Webster RG. Predictions for future human influenza pandemics. *J Infect Dis* 1997(Suppl 1):S14-S19.